

NETWORK CENTRIC WARFARE

Developing and Leveraging
Information Superiority

— 2nd Edition (Revised) —

David S. Alberts
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NETWORK CENTRIC WARFARE Alberts • Garstka • Stein



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Preface

It will be decades before the real book on Network Centric Warfare will be written. This effort is designed to help prepare for the journey that will take us from an emerging concept to the fielding of real operational capability. The success of any journey depends in great measure upon the preparations made. These preparations include a shared sense of purpose, a destination, education and training, and provisions. Many challenges remain. One that is already causing problems is not having a concrete destination, but rather a broad vision of the characteristics of the destination. In a journey such as this, the process becomes the concrete objective for those who are guided by a vision. It is hoped that this book will contribute to the preparations for this journey in two ways. First, by articulating the nature of the characteristics of Network Centric Warfare (NCW). Second, by suggesting a process for developing mission capability packages designed to transform NCW concepts into operational capabilities. The CCRP is continuing to work with others to undertake research and outreach initiatives aimed at developing a better understanding of network-centric concepts and their application to national security. We are interested in hearing about your efforts and ideas.

Given the velocity of the evolution of ideas and experiences about NCW, it is impossible for a “print media” to keep up. Consequently, we find ourselves literally updating and expanding the material in this

manuscript from the moment it left on its journey to the “presses.” While we may in the future publish an updated edition, readers should visit the CCRP website at www.dodccrp.org for updated versions and additional material on the subject.

A handwritten signature in black ink, appearing to read "David S. Alberts". The signature is fluid and cursive, with the first name "David" being more prominent and the last name "Alberts" following in a similar style.

David S. Alberts
Director, Research OASD(C3I)

Introduction

War is a product of its age. The tools and tactics of how we fight have always evolved along with technology. We are poised to continue this trend.¹

Warfare in the Information Age will inevitably embody the characteristics that distinguish this age from previous ones. These characteristics affect the capabilities that are brought to battle as well as the nature of the environment in which conflicts occur.

Often in the past, military organizations pioneered both the development of technology and its application. Such is not the case today. Major advances in Information Technology are being driven primarily by the demands of the commercial sector. Furthermore, Information Technology is being applied commercially in ways that are transforming business around the globe.

The purposes of this book are to describe the Network Centric Warfare concept; to explain how it embodies the characteristics of the Information Age; to identify the challenges in transforming this concept into a real operational capability; and to suggest a prudent approach to meeting these challenges.

In the commercial sector, dominant competitors have developed information superiority and translated it into a competitive advantage by making the shift to network-centric operations. They have accomplished

this by exploiting information technology and coevolving their organizations and processes to provide their customers with more value. The coevolution of organization and process is being powered by a number of mutually reinforcing, rapidly emerging trends that link information technology and increased competitiveness.

Similar concepts are beginning to take root in military thinking, new concepts, plans, and experiments. It is for this reason that developments in the commercial sector are significant and worthy of note, for they provide insights into the potential power of information superiority in the conduct of military operations.

Network Centric Warfare is the best term developed to date to describe the way we will organize and fight in the Information Age. The Chief of Naval Operations, Admiral Jay Johnson, has called it “a fundamental shift from platform-centric warfare.”² We define NCW as an information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. In essence, NCW translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace.

Joint Vision 2010's (JV2010) parallels to the revolution in the commercial sector are striking, with JV2010's stated emphasis on developing information superiority and translating it to increased combat power across the spectrum of operations, as well as the key role of

experimentation in enabling coevolution of organization and doctrine.

To reach its full potential, Network Centric Warfare must be deeply rooted in operational art. As such, we cannot simply apply new technologies to the current platforms, organizations, and doctrine of warfare. There is ample historical precedence for the coevolution of organization, doctrine, and technology in the warfighting ecosystem. For example, performance advantages at the platform level have often led to the emergence of new doctrine, tactics, techniques, or procedures. During World War II, Army Air Corps commanders increased the survivability and lethality of daylight bombing operations by coevolving tactics to exploit the improved range and endurance capabilities of the P-51 and the improved capabilities of the Norden Bombsight to conduct daylight precision bombing with fighter protection for the otherwise more vulnerable bombers.³⁴ Similarly, coevolution played a key role in the eventual Allied victory in the Battle of Britain. In this decisive air campaign, the introduction of radar coupled with the change it enabled in the command and control structure and system provided Allies with a critical competitive advantage.⁵ Consequently, as we continue to apply emerging information technologies, we should not be surprised by the need to explore new warfighting concepts that employ new organizations or new processes.

Different organizations have different time constraints with respect to change. Within the private sector there are many organizations in the vanguard of a shift to network-centric operations. These organizations provide us with a look into a possible future. We need

to closely examine the experiences of these organizations and if they are applicable, apply the lessons learned.

We set the stage with a discussion of the myths currently circulating about NCW; a description of the nature of the changes taking place in the commercial sector, and a discussion of their implications for military organizations and operations. The concept of NCW is then introduced and reviewed in detail. Given the profound implications for how the military organizes, equips, trains, and fights, we then address the process by which technology is introduced into organizations. The book concludes with a discussion of the road ahead and a strategy for moving from NCW-based concepts to NCW-based operations.

Since successful adoption of NCW requires a cultural change, it cannot be achieved without widespread discussion, debate, experimentation, and ultimately, broad acceptance. If this book stimulates and contributes to this process, it will have achieved its intended effect.

NCW Myths

We are sure that many readers have already read a lot and heard a lot about Network Centric Warfare (NCW). Certainly there is no shortage of exaggerated claims, unfounded criticisms, and just plain misinformation about this subject. Sorting out fact from fancy will be among the community's principal tasks as we grapple with how to apply network-centric concepts to military operations. The following discussion of a number of myths currently circulating about the nature, limitations, and dangers of Network Centric Warfare will set the stage for the detailed exploration of Network Centric Warfare concepts offered here. It will do so by alerting the reader to a number of important issues that must be addressed and widely understood if we are to achieve the critical mass of consensus needed to rapidly move ahead.

The Myths

Myth 1: We are experts on NCW and this book has all of the answers.

The truth is that we are not experts on NCW and far more importantly, in our opinion, no one is. In fact at the current time, NCW is far more a state of mind than a concrete reality. Despite this, scattered evidence is now beginning to emerge in the form of "existence proofs" that document the value-added provided by NCW capabilities. These are referenced in later sections. This book will be only one of many attempts

to understand and explain the concepts of NCW and their application to specific military organizations and operations. It will be some time before the full potential of NCW concepts will be understood and even more time before we begin to realize their potential. We need to move beyond bumper stickers to fully explore and debate this important subject. It is our hope that this book will stimulate and contribute to such a discourse, helping to make all of us more aware of the potentials and pitfalls of NCW.

Translating this concept into a real operational capability requires far more than just injecting information technology in the form of an information infrastructure or *infostructure*. It requires concepts of operation, C2 approaches, organizational forms, doctrine, force structure, support services and the like—all working together to leverage the available information. We call this a Mission Capability Package (MCP). How NCW concepts will ultimately be manifested in Mission Capability Packages designed to leverage Information Superiority is the central question we all face. The answer, despite premature predictions to the contrary, will unfold only after much hard work.

Myth 2: NCW is all about the network.

Actually, NCW is more about networking than networks. It is about the increased combat power that can be generated by a network-centric force. As we will show, the power of NCW is derived from the effective linking or networking of knowledgeable entities that are geographically or hierarchically dispersed. The networking of knowledgeable entities enables them to

share information and collaborate to develop shared awareness, and also to collaborate with one another to achieve a degree of self-synchronization. The net result is increased combat power.

Myth 3: NCW will change the nature of warfare.

Obviously, the word nature means different things to different people, but if you take a look at the principles of war, only the principles of mass and maneuver need to be somewhat reinterpreted to reflect the massing of effects, not forces. The other principles remain as meaningful as ever.

NCW does however offer us an opportunity to improve our ability to achieve these principles by reducing the tensions among them. We will show that the principles related to the offense, economy of force, surprise, and unity of command can clearly be helped by the application of NCW concepts. And despite some well-founded concern, we believe NCW can also contribute to achieving the principle of simplicity.

Myth 4: NCW applies only to large-scale conflict with a peer competitor.

If one associates NCW with the kind of tactical sensor-to-shooter low hanging fruit that early experiments are focusing on, then one might be tempted to reach this conclusion. However, if one takes a look at the principles of war, which apply pretty broadly across the mission spectrum, then one is forced to conclude otherwise.

For example, the principle of offensive is to act rather than react and to dictate the time, place, purpose,

scope, intensity, and pace of operations. This is all about battlespace awareness, speed of command, and responsiveness. As will be demonstrated later in this book, the application of NCW concepts has enormous potential for improving our ability to achieve battlespace awareness, speed of command, and force responsiveness. We will also show that the application of NCW concepts have proven useful in Operations Other Than War (OOTW) including *Desert Fox*, *Deliberate Force*, and in Bosnia.

While it is true that our collection systems are not currently designed for OOTW, this does not negate the promise that NCW has for improving upon our current approaches to these kinds of operations. Thus, rather than saying that NCW is not applicable to OOTW, it would be more accurate to say that we could not hope to fully realize the promise of NCW without proper attention to the collection and analysis of appropriate information. But even in the case where information is far less than perfect, it could reasonably be argued that being able to have a shared understanding of what is known and what is not known would be preferable to a situation in which units operated in isolated ignorance.

Myth 5: NCW makes us more vulnerable to asymmetric attacks.

We are, of course, far too vulnerable for comfort. We cannot tell you NCW will make us less vulnerable. The truth is that nobody knows. This is because it depends on how the concepts of NCW are translated into concepts of operation, doctrine, force structure, and each of the other elements that comprise a mission

capability package. Our increasing dependence on our “system of systems” and our potential vulnerabilities to problems like Y2K, information warfare, or simply malfunctions due to sheer complexity should give us pause. These vulnerability issues need to be more fully explored as the number of our systems and our dependence upon their proper functioning continues to grow and as they individually and collectively become more complex.

However, it would be foolish to discard the concept of NCW because of these concerns. Rather we need to keep our vulnerabilities in mind as we proceed to define and build our future infostructure and take steps to rigorously test proposed NCW solutions, subjecting them to information attacks.

Myth 6: We are already well on the road to NCW.

To fully leverage Information Superiority and apply the concepts of NCW to the full range of tasks we in DoD undertake in support of our many mission challenges, two things are required—first, a suitable infostructure and second, coevolved mission capability packages.

While we are taking steps in the right direction, and indeed are making useful progress, unless we take appropriate action now, we will fall short in both areas, hampering our ability to make further progress. First, the infostructure we can reasonably expect, given current plans, investments, and acquisition processes will have shortfalls in several significant dimensions. We can expect continued vulnerabilities, a lack of connectivity and bandwidth, particularly for that stubborn last mile, and problems with mobility and

survivability. One problem we grapple with is the program-centric way we acquire capabilities. Another is the need for improved approaches to the challenges associated with integrating a federation of systems.

Second, unless we do a better job of nurturing and rewarding innovation, our applications of NCW concepts are more likely to be linear extensions of current concepts and practices rather than being truly innovative. We may be thus trapped in a vicious cycle, where a lack of infostructure will hamper the ability of innovators by making it difficult to imagine what is possible and to test out new ideas, and by making the concepts that are developed seem beyond reach.

Myth 7: The commercial world has shown us the way, all we need to do is follow.

In fact, network-centric concepts do not automatically translate into effective organizations. This is true whether or not one is trying to apply this concept in the commercial sector or to DoD. This assertion that “what is good for business is good for DoD” is a dangerous oversimplification. However, the converse assertion that “lessons learned in the commercial sector have no application to the domain of warfare” is equally untrue and if believed, would deny us an opportunity to learn from the experiences of others when they are applicable.

Myth 8: NCW will give us the power to dominate our adversaries.

Obviously, anyone that claims that NCW concepts are “the answer” clearly misunderstands what NCW is all

about. As we will show, NCW allows us to get the most out of our people and our assets. However, better awareness depends upon not only sharing what we know but also upon our ability to collect and analyze needed information. Improved collaboration, speed of command, and other attributes of command and control will not make up for weapons that are insufficient or inappropriate for the task at hand. Thus, it is important to remember that we need balanced mission capability packages to satisfy our operational warfighting requirements.

There are some types of operations that we are not as well equipped to do as others. Clearly, in some of these cases we need to invest in other capabilities in order to make significant gains. Thus, while NCW has the potential to improve upon current performance, it is clearly not a panacea.

Myth 9: NCW will not survive first contact with the real fog, friction, and complexity of war.

The fact that warfare will always be characterized by fog, friction, complexity, and irrationality circumscribes but does not negate the benefits that network-centric operations can provide to the forces in terms of improved battlespace awareness and access to distributed assets. While predicting human and organizational behavior will remain well beyond the state of the art, having a better near real-time picture of what is happening (in situations where this is possible from observing things that move, emit, etc.) certainly reduces uncertainty in a meaningful way. We would argue that better battlespace awareness and increased responsiveness could help us shape the

battle to our advantage. This notion is not new, but an extension of the classic principal of offensive. NCW concepts hold the promise of giving us more to work with.

Myth 10: NCW is an attempt to automate war that can only fail.

NCW is not about turning the battle over to “the network” or even about relying more on automated tools and decision aids. It is really about exploiting information to maximize combat power by bringing more of our available information and warfighting assets to bear both effectively and efficiently. NCW is about developing collaborative working environments for commanders, and indeed for all our soldiers, sailors, marines, and airmen to make it easier to develop common perceptions of the situation and achieve (self-) coordinated responses to situations. However, there is definitely a place for automated tools and decision aids on the battlespaces of the future. As we will explain, there are different types of decisions to be made and different tools and approaches to these decisions are appropriate. Potentially, a lot could be gained from the prudent application of automated processes—arguments *ad absurdum* notwithstanding.

Myth 11: NCW will result in our chasing our tails rather than responding to battlespace events.

There has been some concern voiced about NCW’s effect on the speed of command. The worry is that we will develop a pace that is so rapid that we will “get ahead of ourselves” on the battlefield, responding not to an adversary’s actions and reactions, but to

ourselves (chasing our tails, as it were). Obviously, one can easily construct situations and circumstances where “speed of command” is irrelevant or worse, harmful. But there are many circumstances and missions where, all things being equal, speed of command will be decisive. The point is that NCW gives us an opportunity to increase speed of command when it is appropriate; it does not force us to do so when it is not. Thus, the point we can take away is the need to better understand how we can leverage speed of command in military situations and dispel the myth that speed (or any other single factor) is either a panacea or an unmitigated good.

Summary

It is important to realize that each of these myths contains the germ of a valid concern. It would be unfortunate if, because of the way in which these concerns are expressed, they were not given due attention as we proceed on our journey into the future.

The Information Age

Recent advances in Information Technologies (IT) and the ability of organizations and individuals to take advantage of the opportunities these advances provide are profoundly altering the nature of the world in which we live. The Information Age is:

- 1) changing how wealth is created;
- 2) altering the distribution of power;
- 3) increasing the complexity;
- 4) shrinking distances around the world;
and
- 5) compressing time, which increases the tempo of our lives.

This chapter examines the nature of those changes.

The Technology

Information Technology is the DNA of the Information Age—the fundamental building block of dominant competitors. The underlying trends in Information Technology (which are discussed in Appendix A) are coalescing to create *orders of magnitude increases* in the ability of human beings to operate in the information domain. At the most basic level, the primary observable of this quantum improvement in the information domain can be observed in the dimensions of speed and access.

Across a broad range of activities and operations, the time required by individuals to access or collect the information relevant to a decision or action has been reduced by orders of magnitude, while the volume of information that can be accessed has increased exponentially. In some competitive domains, the timelines for creating value have been reduced from hours to seconds (e.g., on-line trading). Consequently, across a broad range of value-creating activities, the fundamental limits to the velocity of operations are no longer governed by space or time. Instead, the fundamental limits are governed by the act of deciding, by the firings of neurons, by the speed of thought.

Clearly, these revolutionary changes in the information domain have the potential to have the same level of impact on the fabric of society that previous revolutionary technologies have wrought (e.g., the steam engine, the internal combustion engine, the airplane). These changes created new opportunities for creating and distributing wealth and power. At this phase of the Information Age, it is clear that we are poised to continue compressing time and space beyond the physical limits of the Industrial Age.

Wealth and Power

The original recipe for wealth creation featured land, labor, and capital as its key ingredients. In the Industrial Age the relative importance of land diminished as factories required mainly capital and labor. Capital was needed for machinery and raw materials. The demand for labor, still needed for

production, abated somewhat as productivity increased.

Creating wealth involves adding value, turning raw ingredients into products. Energy in one form or another is required to accomplish this transformation. Our progression from one age to another has been propelled by a change in the source of energy, freeing us from former constraints and making energy more available and less expensive. In the Age of Agriculture, primarily humans and beasts of burden supplied energy. Steam, the combustion engine, and electricity derived from a variety of fossil fuels fueled the Industrial Age. Later, nuclear energy was added to the mix. In the early stages of the Information Age, we continue to use large quantities of the fuels associated with past ages, but as technology advances, we require less and less power and hence less of the traditional fuels to accomplish a given task.⁶

The explosive growth in wealth and the changes in its distribution we are experiencing in the Information Age are being driven by three factors. All involve information, one as a product, one as a raw material, and the third as a fuel.

The nature of the product mix has changed over time. Products were once exclusively a mix of natural materials with minimal processing (e.g., food, fibers, stone, and wood). This changed to a mix that was dominated by invented and manufactured products. Information and intellectual property are now playing increasingly important roles as their percentage of the mix increases. The importance of information as

a raw material will increase with the proliferation of products that are manufactured from information. These information products serve as fuel for other enterprises in the processes that add value to their raw materials. There is hardly an enterprise anywhere that does not increasingly rely on information products to keep abreast of its competition or to make itself more productive. Many organizations now devote significant amounts of resources to collect and mine the information that is integral in their day-to-day operations (e.g., using the information collected by point-of-sale scanners to understand the buying habits of customers). Others subscribe to a variety of information services whose aim is to reduce uncertainty. Information is playing an increasingly important role in the processes that add value to raw materials, whether these raw materials are in the traditional sense animal, mineral, or vegetable or whether the raw material is ideas.

In some enterprises, information is the main raw material, the predominant fuel, and the product (e.g., information services such as Bloomberg and Reuters). In Information Age factories, products such as software, once developed, can be duplicated and distributed at very low marginal costs. Ideas, always important, now for the first time can result in the creation of wealth without a substantial capital investment.

Wealth and power have always been closely interrelated, with significant capital being necessary to obtain the instruments of power (weapons and armies). Today's world is, in some ways, a far more dangerous place because more players can afford

the investments needed for weapons of mass destruction (WMD) and terror. The affordability of WMD is reaching a level where they are no longer the exclusive property of nation states. They can now be increasingly found in the arsenals of terrorists, financed by rogue states or even wealthy individuals. The advent of Information Warfare exacerbates the problem. The tools and techniques of information war are even less expensive and more widely available than the traditional WMD. Moreover, the havoc they could wreak is not yet fully understood. Imagine what would have happened if tanks, planes, ships, and munitions could be copied and distributed like software. The platforms and weapons of information warfare can.⁷

But weapons are not the only instruments of power. Information, as it has often been said, is power. But when this expression was coined, information (like WMD) was a relatively rare, expensive, and restricted commodity. This saying is more applicable today than ever, but in a different sense. Information technologies are greatly improving our ability to collect and store data, process and analyze it to create information, and distribute it widely. Information is being transformed from a relatively rare product into a plentiful one; being turned from an expensive commodity into an inexpensive one; and being freed from the control of a few to make it almost universally accessible.

The increasing availability and affordability of information, information technologies, and Information Age weapons increases the potential for creating formidable foes from impotent adversaries.

This explosion of information is affecting the distribution of power among and within societies, both democratic and autocratic alike, by increasing public awareness. Not only are people more aware of what is going on and of views that may not conform to those of their governments, but the governments are more aware of what the people are thinking. All of this is happening in real time. Fewer and fewer governments can risk the loss of public support. Thus, we are seeing a shift of power to the people unequaled in history.⁸

In a parallel movement, more organizations and institutions are becoming international and transnational as the Information Age has reduced the importance of location and contributed to the process of globalization. The interests of these organizations are becoming less aligned with those of particular governments. Taking sides in conflicts between countries is usually not in these organizations' self-interest. This also represents a shift in the distribution of power, creating more players on the world stage.

Complexity, Time, and Space

The proliferation of significant players and the global nature of markets and economies are increasing the complexity of doing business, whether that business is in the public or private sectors. Complexity is increasing in large part due to the impact that the Information Age is having on the dimensions of time and space.

The Information Age is making distance less relevant. Information, and the decisions that result, can travel

almost instantaneously to the place(s) where they are needed, making the location of those who gather, analyze, make decisions, and possibly those who act on these decisions, largely irrelevant.

The Information Age is also compressing the time dimension. First, by making location less important, it reduces the need for time-consuming travel, whether local or long distance. Second, to the extent that information gathering, analysis, and decision making are activities on the critical path, advances in Information Age concepts and technologies are compressing process cycle time. The intensity of these effects is more pronounced in the many processes where information is playing an increasingly important role.⁹

These changes in the dimensions of time and space are increasing the pace of events, or operating tempo, in many different environments. This phenomenon is seen in the rapid fluctuations of the stock market around the world, in the shortening half-life of a breaking news story, in the shrinking time it takes for a product to reach the market, and in the waning attention span of the public. Responsiveness and agility are fast becoming the critical attributes for organizations hoping to survive and prosper in the Information Age.

In the Darwinian world of business, those organizations that are emerging as winners are those that can be described as being *information enabled*. These organizations have found ways to leverage the available information and make the right decisions and right products quickly and efficiently.

The emergence and ascendancy of information-enabled organizations is the result of coevolution in the domain of business. Coevolution, in the sense we use it in this book, is derived from the Santa Fe Institute's research into complex adaptive systems. Biologists have observed that over a large number of life times, species coevolve with each other. We apply this logical construct to the domain of warfare where concepts of operation coevolve in response to changes in their ecosystem.¹⁰ These changes can be quite diverse and include changes in the geopolitical landscape, social and economic changes, changes in the nature of the threat, and advances in technology. In the domain of warfare these ecosystem changes serve to stimulate a series of interrelated changes in concepts of operation, doctrine, organization, command and control approaches, systems, education, training, and people. All these elements come together to form mission capability packages designed for specific tasks and missions.

Summary

Even at this early stage of the Information Age, we are experiencing profound changes in the nature of our world. Wealth and power, for so long the providence of the few, are being created with new time constants and distributed far more widely. For example, it is now possible for entrepreneurs behind successful Internet-based companies (e.g., Yahoo, Amazon.com, and eBay) to become billionaires in periods measured in months, and for the public to share in this value-creation process.¹¹ This is creating a plethora of significant new players. Among these are the

public who have been empowered by information; transnational organizations that have been created by the phenomenon of globalization; and a host of state and non-state adversaries made more dangerous by the proliferation of the instruments of power, including WMD and Information Warfare. The Information Age has also resulted in greatly increased complexity arising out of a need to deal with more players and at a much faster operating tempo.

Information Age Organizations

Commercial organizations are leading the way in adopting Information Age concepts and technologies and in adapting to a changing world. These organizations are being driven by a need to keep abreast of invigorated competition, facilitated by the lowering of barriers to entry and by the elimination, or reduction, in the competitive advantage that established organizations have developed and held for some time. These incumbent advantages have been eroded by changes in cost structures, methods of production and distribution, and characteristics of the marketplace resulting from the introduction of Information Age concepts and technologies.

There have been striking successes and notable failures. By and large, organizations that have been able to fully leverage the power of information and information technologies (IT) to develop a competitive advantage have dominated their competitive domains. Those that have been slow to recognize the potential for information and information technologies to transform their organizations and processes, or have failed to go far enough and fast enough to change the way they do business, are being acquired by their competitors or swept away.

This chapter focuses upon the lessons that can be drawn from the experiences in the commercial sector.

We begin by first examining the underlying value-creation processes that are central to developing competitive advantage, then the role played by information and information technologies in enabling and enhancing these processes. The chapter concludes with some examples of how successful organizations have become dominant in their competitive domains by employing information-based strategies and translating information superiority to a competitive advantage.

Some have argued that insights from other domains, such as those we will be drawing from the commercial sector, are not really relevant to military organizations because business is not warfare.¹² It is true that business is not warfare. Myth 7 clearly addresses the inappropriateness of attempting the wholesale transfer of experience from the business domain to the domain of warfare. But to dismiss a potentially rich source of hypotheses for us to examine is as foolish as it is unnecessary. While caution is the watch word, there is a good argument to be made that the basic dynamics of the value-creation process are domain independent. Further, there are significant insights that can be gained from the experiences of dominant competitors who have successfully exploited information technology to create competitive advantage. We see the lessons learned in the commercial sector not as gospel to be blindly followed, but as inputs to our concepts, development, and experimentation processes.

History supports the view that valuable insights have relevance across disparate domains. A fundamental lesson that has emerged from multiple domains, including business and warfare, is that the power of a new

technology cannot be fully exploited to create competitive advantage without the simultaneous coevolution of organization and process. This lesson has been learned by those who have explored how militaries have exploited advances in warfighting technologies, such as the long bow, the rifled barrel, the machine gun, the tank, the airplane, radar, and telecommunications. Each of these technologies changed the complexion of warfare. Some of these technologies (airplane, radar, and telecommunications) also had significant commercial applications. In both military and commercial applications, it can be seen in retrospect that effective exploitation of these technologies required the coevolution of organization and doctrine. Thus, technologies have not only migrated from warfare to other domains, but from other domains to warfare. The lessons generated in the initial domain of application have proven useful to those in other domains.

The predominant market for information technology today is the commercial sector. Presently, the defense sector represents a relatively small fraction of the \$600-billion-plus information technology market (the percentage varies between 1- and 10-percent-plus of the total market for computing and terrestrial communications, but is much higher for some segments, such as communications satellites).¹³ Consequently, the commercial sector is the competitive space with the preponderance of case studies that address the coevolution of organization, process, and information technology in creating competitive advantage. The trajectory of innovation associated with creating competitive advantage in the commercial sector is portrayed in Figure 1, *Coevolution and the Shift to Network-Centric Operations*. This

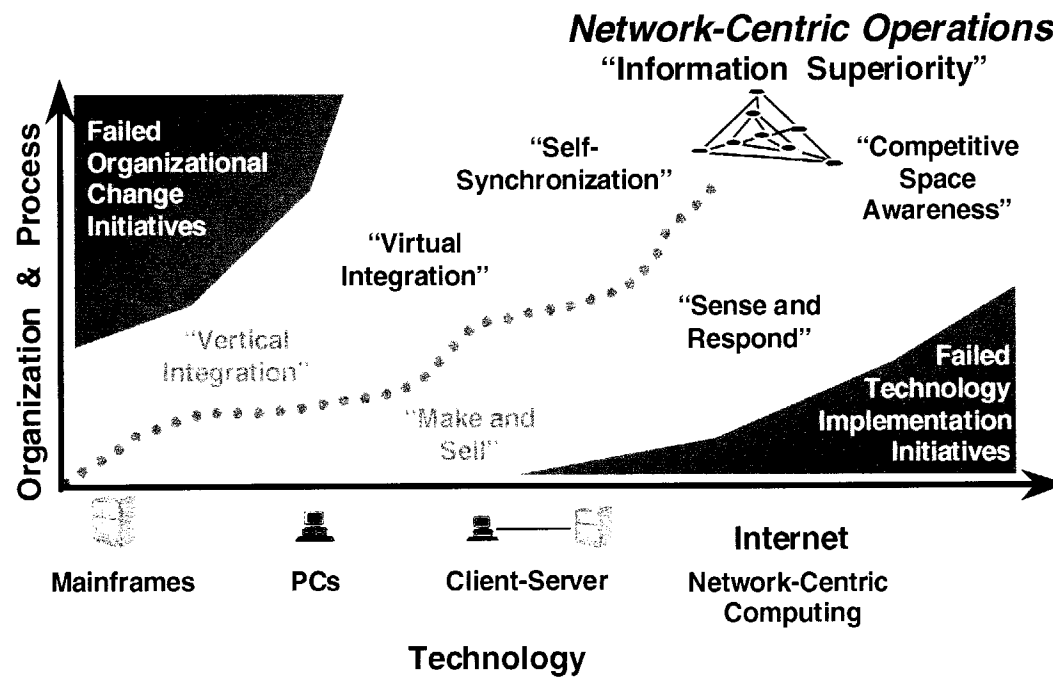


Figure 1. Coevolution and the Shift to Network-Centric Operations

figure highlights the imperative to simultaneously pursue the changes in organization, process, and technology highlighted in the case studies that follow, and to avoid change efforts that focus on only a single dimension of the solution space. The insights that we can gain from the commercial sector can help make DoD a preeminent Information Age organization.

Value Creation

Creation of value is at the heart of creating competitive advantage. As introduced by Michael Porter, the value chain describes the links or processes that transform inputs and/or raw materials into value in the form of products.¹⁴ The value chain concept postulates that competitive advantage can be better understood and hence improved by breaking down the value-creation process depicted in Figure 2 into its constituent parts so that the contribution of each activity to the firm can be assessed. The primary value-creating activities include operations and production, marketing, sales and service, and logistics (both to get the raw material or the inputs to the place where they are processed, assembled, and/or integrated, and get the final product to the customer). Other activities contribute to the value-creation process by playing a supporting role. These support activities include technology development, financial and human resource management, and general infrastructure. The concept of value creation applies equally well to services (referred to as *value shops*, or in the case of brokering or market-creation operations, *value networks*.¹⁵)

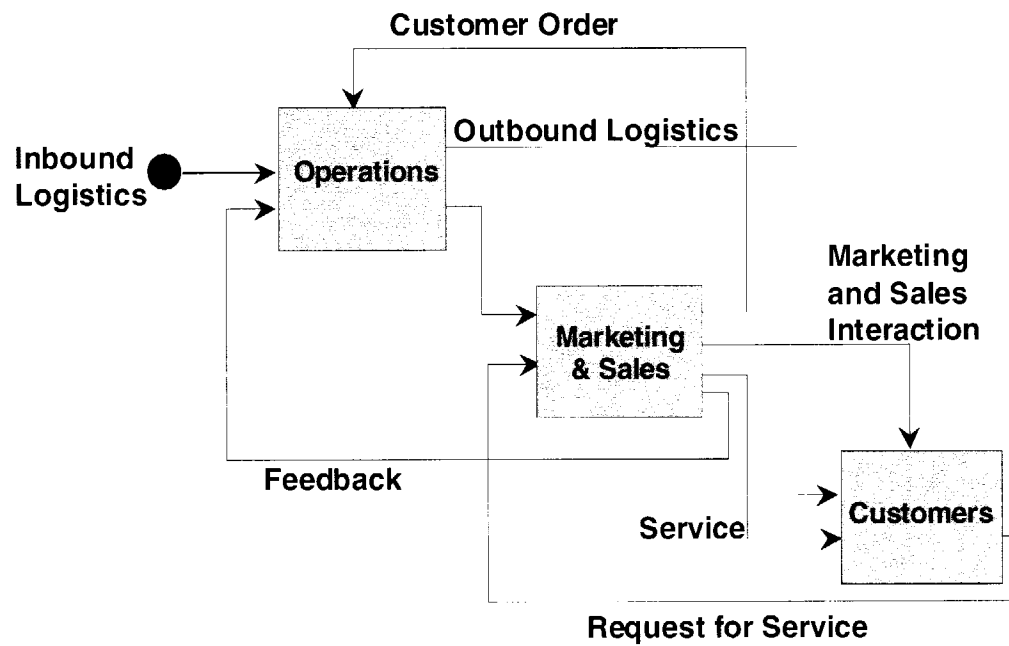


Figure 2. Information Flow in the Value-Creation Process

Figure 3 depicts the key components of the value-creation process. In short, it involves producing an attractive product or service, and making it available in a timely manner at a competitive price.

Increasing competitive advantage requires an increase in the relative value delivered (to customers) vis-à-vis competitors. Value can be enhanced by increasing the attractiveness of a product or service by incorporating the features that customers desire, including the *ilities* (reliability, maintainability, usability, etc.); increasing responsiveness and tempo of operations by reducing time lines (between product innovations and the time from order to delivery); creating concurrent processes; or lowering prices.

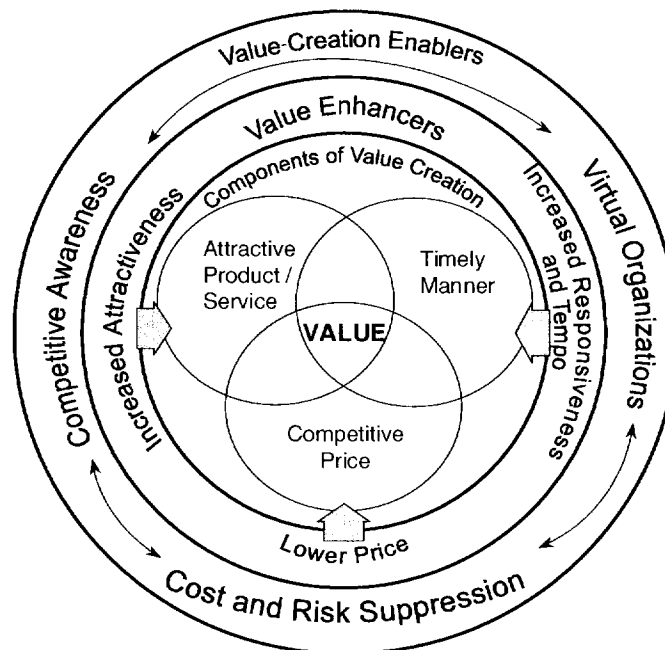


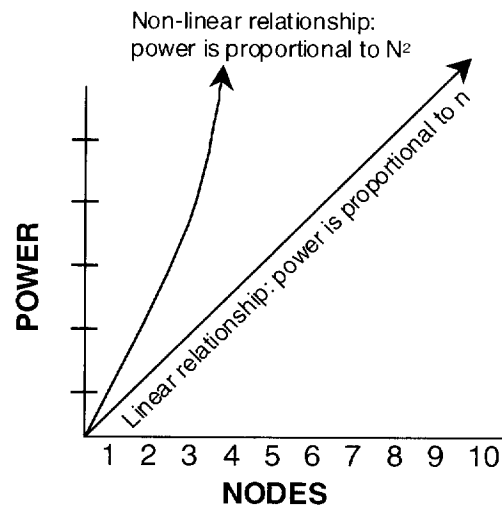
Figure 3. Value-Creation Process

Information and IT are providing the means for innovative companies to create value in ways that were not possible before the advent of the Information Age. The obvious question is: “Where does the value come from, and can it be quantified?”

Insight into the answer to this question is provided by *Metcalfe’s Law*.¹⁶ Metcalfe’s Law (Figure 4) describes the potential value of a network. It states that as the number of nodes in a network increases *linearly*, the potential “value or “effectiveness” of the network increases *exponentially* as the *square* number of nodes in the network.

The source of potential value is a function of the interactions between the nodes. For every “N” node in a network, there are “N-1” potential interactions between the nodes. Therefore, in a network of “N” nodes, the total number of potential value creating interactions is: $N \times (N-1)$, or $N^2 - N$. For large N, the potential value scales with N^2 , or “N squared.” (A more in-depth discussion of Metcalfe’s Law is provided in Appendix A.)

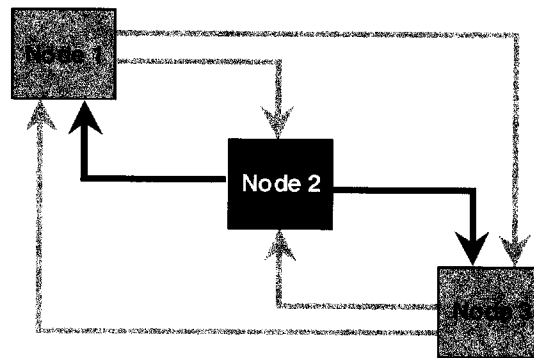
The existence of the network enables the interactions between nodes to be information intensive. We can observe that information has the dimensions of relevance, accuracy, and timeliness. Therefore, an upper limit in the information domain is reached as information relevance, accuracy, and timeliness approach 100 percent. Of course, organizations may not be able to achieve these 100-percent conditions. Consequently, the objective in the commercial sector is to approach these upper bounds faster than a competitor. Figure 5 portrays a superior information



Each node in a network of "N" nodes is capable of initiating "N - 1" interactions

Total number of potential interactions between nodes in the network is:

$$N(N-1) \text{ or } N^2 - N$$



Network with $N=3$ has

$$3 \cdot 2 = 6 \text{ Potential Information Interactions}$$

Figure 4. Metcalfe's Law

position relative to a competitor in the information domain. The objective is to leverage this superior information position to create and maintain a competitive advantage.

Information Superiority is a state that is achieved when a competitive advantage is derived from the ability to exploit a superior information position.

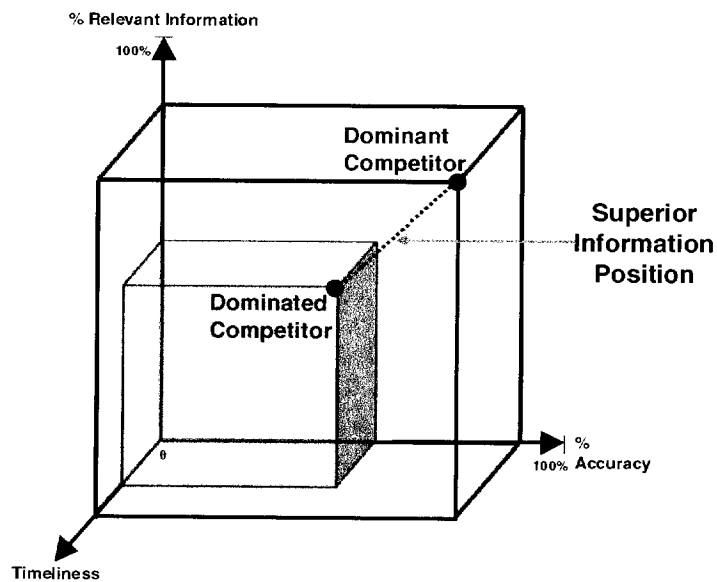


Figure 5. Superior Information Position

The mechanism for creating and exploiting information superiority is a function of the dynamics of competition in a domain of competition. Across broad sectors of the economy, dominant competitors such as Dell Computer Corporation and Cisco Systems (information technology), Federal Express and American Airlines (transportation), Charles Schwab, Deutsche Morgan Grenfell, and Capital One (financial services), and Wal-Mart and Amazon.com (retailing) are successfully employing information-based strategies to create a competitive advantage in their respective domains. Across these domains a number of fundamental themes and concepts have emerged that have coalesced to enable the Network-Centric Enterprise. A Network-Centric Enterprise is characterized by an information-based strategy for creating and exploiting information superiority. The elements of this strategy are depicted in Figure 6.

It all begins with the infostructure ("the entry fee"), which in turn enables the processes that create vastly improved competitive space awareness and share this awareness through the enterprise. This in turn enables a set of processes for exploiting this awareness that results in an improved "bottom line." The remainder of this section explores the nature of the Network-Centric Enterprise.

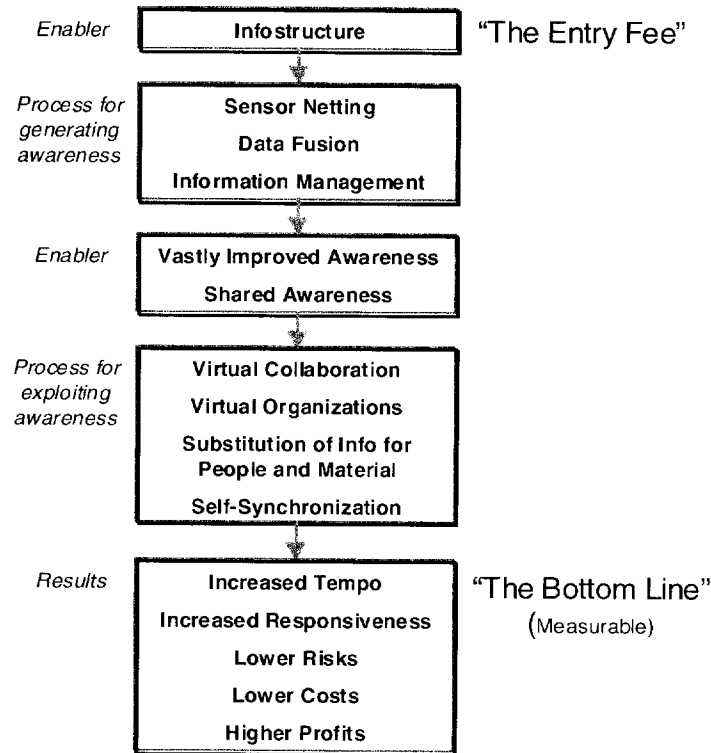


Figure 6. The Network-Centric Enterprise

Competitive Awareness

The ability of a competitive ecosystem to generate and exploit competitive awareness (an awareness of one's competitive domain or competitive space) has emerged as a key enabler of effective decision making and a principle component of competitive advantage in multiple sectors of the economy. As is evident from the case studies discussed later in this chapter, dominant competitors have demonstrated the ability

to generate high levels of awareness of what is going on in their respective enterprises and extended business ecosystems. This high level of awareness has been key to both developing strategy and improving effectiveness at the operational level.

Awareness of one's customers, competitors, and the environment is essential to allow organizations to better understand what the characteristics or attributes of their products or services are or need to be to maximize value. Awareness of customer needs also contributes to improved production, capacity, and logistics planning that, in turn, can improve product availability and reduce business risk. For example, decisions often have to be made on how to allocate finite resources against competing needs.

Consider the decisions that need to be made in outbound logistics when demand for product temporarily exceeds supply. From a purely logistical perspective, it would be hard to fault the logic of filling orders on a first-come, first-serve basis. Although this decision logic might be the easiest for logisticians to implement, it could be far from optimal from an enterprise perspective.

To maximize the return for the enterprise, multiple perspectives and factors have to be considered. The history of customer relationships and urgency of customer needs clearly merit consideration. The net profitability of particular customers is a key factor that may influence allocations. Similarly, accounts receivable is likely to place a priority on credit history. The shipping department is likely to be focused on immediate, already scheduled destinations.¹⁷

The ability of an enterprise to share information across functional areas can enable resource allocation decisions to be made that maximize value from an overall enterprise perspective rather than a purely functional perspective.

Increased awareness of emerging technology will also contribute to leveraging technology to make all of the activities in the value chain more effective and efficient, thus reducing costs and risks. Finally, awareness of the future contributes to the ability to adapt value-creation processes over time to maintain and increase value.

Virtual Organizations

Virtual organizations bring the necessary people and processes together to accomplish a particular task. When the task is over, these resources can be released for other tasks. Virtual organizations, enabled by networking, allow enterprises to take advantage of the potential gains in productivity that are associated with virtual collaboration, virtual integration, and outsourcing. Since networking makes location less important, the opportunities for collaboration, integration, and outsourcing are increased.

Virtual collaboration enables individuals to collaborate in a virtual domain. These individuals can be geographically dispersed. One of the major payoffs of collaboration is an improved product design process—one that is not only faster and less costly, but also produces better designs. Major design efforts, such as the design of aircraft, ships, or automobiles, have been facilitated by the implementation of collaborative

digital design processes.¹⁸ A well-publicized case study is Boeing's success in the design of the 777.¹⁹

Virtual integration enables companies to operate with others as if they were a single, vertically integrated, company. This enables product or market-specific virtual entities to be formed as required to reduce time lines, reduce costs, and improve responsiveness.

Outsourcing is an approach for focusing an organization on its core activities or competencies by divesting activities that must be done but are not where the organization's expertise or experience lies—in other words, areas where it does not possess a competitive advantage. Many organizations have found that outsourcing some of their activities to companies that specialize in a particular service can achieve economies of scale, keep them current with the latest in concepts and technology, or relieve them of the burden of a non-core function. Increasingly, companies have employed outsourcing to accomplish key supporting functions such as information infrastructure, facilities and logistics management, and legal and accounting services. In some cases, activities that used to be considered primary, such as production, have been outsourced and bought as a commodity or turnkey operation. For example, computer manufacturers Compaq and IBM use Ingram Micro to assemble some of their computers. Another example is provided by Sara Lee, which recently announced that it was going to outsource key aspects of production and focus on marketing and product development.²⁰

Virtual organizations reduce time lines and increase the tempo of operations. They do this by turning 8-hour days into 24-hour days, by reducing dead times in processes, and by facilitating concurrent processing. In many sectors, increasing the tempo of operations is the key element in achieving competitive advantage. It contributes to reducing costs as well as differentiating products or services based on responsiveness to customer needs. Successful organizations have been able to increase the tempo of their operations by organizing in a manner that allows them to leverage both available information and available assets.

Additional gains can be realized when some of the *collaborators* are, in fact, automated processes or *expert* systems that can provide both greatly increased functionality and simultaneity, along with significant reductions in task processing time.

One of the benefits of adopting network-centric operations is the ability to work projects continuously across time zones. For example, IBM is one of the many companies that now develops and tests software across multiple time zones. After a design team in one location finishes a day's work, another software design team in a separate time zone picks up the ball to continue additional development or testing. Sun Microsystems employs a similar approach to provide support to customers worldwide on a 24-by-7 basis. This basis of "following the sun" can provide significant competitive advantage when time-to-market or service responsiveness is a key source of competitive differentiation.

Cost and Risk Suppression

The ability to use information to suppress costs and reduce prices is at the core of numerous information-based strategies. Many of the approaches for accomplishing cost suppression have been discussed previously. They range from very high payoff, such as being able to reduce the amount of scrap generated in building a large aircraft, (e.g., the Boeing 777²¹) to the truly mundane, such as reducing the time and cost of processing travel claims. There is also the capability in many situations to reduce the need for travel by exploiting video teleconferencing.

A key theme of cost suppression, of which the Boeing 777 is but one example, is the ability to substitute information for inventory. The capability to effectively accomplish this can have a truly significant impact on competitive advantage. As will be evident from the examples that follow, the ability of Wal-Mart and Dell Computer to substitute information for inventory is key to their achieving a competitive advantage.

Risk translates directly into increased costs and/or reduced value. Hence, the reduction of risk and its proper management are an inherent part of value creation. Information (competitive awareness) is, of course, a key to risk suppression.

For example, Capital One, a leading provider of consumer credit, employs very sophisticated analytic techniques to manage operational risk in several ways. First, they employ powerful analytic tools to identify those customers which are likely to have the lowest rates of defaults on their credit card balances. Second,

they then exploit this information to focus their marketing efforts on these customers. Third, they employ equally sophisticated tools to align credit card limits with estimates of income and exposure to minimize losses in the event that a customer defaults on loan amounts. The net result of the combination of these approaches is an information-based strategy for managing operational risk that provides significant competitive advantage.²²

As will be evident from the Dell Computer Corporation example, Dell's ability to substitute information for inventory not only reduces the cost of goods sold, it also significantly reduces two of the primary sources of operational risk: excess parts inventory and excess inventory of finished products.

The examples that follow all serve to illustrate how organizations in the commercial sector are achieving dominant competitive positions that are enabled by information superiority. The first example shows how manufacturing can become precision manufacturing. The second example looks at the transformation of logistics into focused logistics, while the third looks at an example of precision retailing. The final example looks at a case where the *product* is, in and of itself, unique to the Information Age.

Precision Manufacturing

Dell Computer Corporation provides an example of how information can be used to create a competitive advantage in a value chain. Dell Computer Corporation is the world's leading direct computer systems company, with revenues of \$18.2 billion for the fiscal

year ending February 1, 1999 (up from \$12.3 billion for the previous fiscal year, a 48 percent increase). Central to Dell's strategy for creating value is its direct sales model, which offers in-person relationships with corporate and institutional customers; telephone and Internet purchasing; phone and on-line technical support; and next-day, on-site product service.²³

This approach enables Dell to "*sense and respond*" to producing products only when there is real demand.²⁴ As a result, Dell has developed a significant competitive advantage over the "*make and sell*" strategies of their competitors. Dell forges strong direct relationships with customers, which among other things allows it to more precisely *sense* the types and kinds of product attributes that are important to various segments of its customer base. This translates into being able to design more attractive products. Equally important, the direct model enables rapid *response* to customer demand while simultaneously reducing operational risk as well as the cost of the end product.

The rapid pace of innovation in the information technology sector provides both risks and opportunities. Two of the primary sources of operational risk are large inventories in the form of excess finished product and obsolete or high priced components (e.g., CPUs, RAM, hard drives, batteries). In some cases, the need to write off excess product and parts inventory has erased an entire quarter's profits.²⁵ By producing only systems that customers have ordered, Dell minimizes the risk associated with product inventory. Dell reduces risk further by operating with reduced levels of component inventory, which are as small as 11 days for some components. This provides Dell with the capability to

respond more quickly than competitors (who in some cases operate with levels of inventory that are over five times larger) when new component technology becomes available, or when prices for existing component technology drop.

Minimizing operational risk in this fashion requires a shift in focus from how much inventory there is to how fast the inventory is moving. Dell manages the *velocity of inventory* by using a constant flow of information to drive operating practices, from performance measures to how they work with suppliers. Dell describes its relationship with its suppliers by using the term *virtual integration*. Virtual integration requires an intensive real-time sharing of information between Dell, its customers, and its suppliers. The ability to share information in near real time among all relevant elements of the ecosystem enables Dell to *substitute information for inventory* and to simultaneously increase flexibility and responsiveness. The near real-time sharing of information within the enterprise provides decision makers with a common operational picture that helps facilitate self-synchronization as well as increase the tempo and responsiveness of operations.

Focused Logistics

In the transportation sector, traditional organizations are entirely focused on the basic service of moving objects from one place to another. In the Information Age, information in the form of in-transit visibility has been added to the *product* to transform logistics into focused logistics. For many customers, this information component of the transportation service often makes or breaks their ability to succeed.

In rail-based shipping, companies such as Union Pacific and CSX now deliver transportation services by combining a primary rail network with a supporting information network. Similarly, shipping companies such as Federal Express and United Parcel Service now employ a primary hub and spoke architecture supported by an information network. The supporting information networks employed by these companies integrate both sensing and transaction capabilities. The sensing capabilities employ networked sensors to generate near real-time awareness on the status and locations of 100 percent of their shipments.²⁶ In the case of railroads, this translates to thousands of boxcars daily, and in the case of Federal Express and United Parcel Service, daily shipping volume is measured in millions of packages. The ability to generate a high level of awareness has been key to helping these companies identify sources of operational problems and significantly improve their operational performance.²⁷ Furthermore, the deployment of network enabled transaction capabilities provides customers with operational capabilities for performing on-line transactions (such as placing an order for transportation services, or modifying a transportation request) as well as providing in-transit visibility, in near real time. Thus, these innovative companies differentiate their services in two ways: improved on-time delivery and increased in-transit visibility.

Precision Retailing

In the transaction-intensive retail sector, dominant competitors have used information superiority to create a competitive advantage by adding information to retailing to achieve precision retailing. The recognized

leader is Wal-Mart. In 1997, Wal-Mart had earnings of \$3.334 billion on sales of \$113.42 billion.²⁸ These sales were generated by a worldwide operation consisting of over 3,000 stores supported by over 1,800 suppliers. Part of Wal-Mart's superior competitive position results from its ability to significantly reduce its distribution costs, which some have estimated to be less than 3 percent of sales, versus 4½ to 5 percent for the competition.²⁹ In a sector where margins are razor thin, the relationship between these reduced distribution costs and Wal-Mart's profitability is clear. Furthermore in this light, Wal-Mart's ability to reduce inventory in 1997 by over \$1 billion can be seen as a truly significant accomplishment.

The competitive advantage that enables this cost suppression emerged when Wal-Mart realized that it could not cost effectively synchronize supply and demand from the top down. Wal-Mart has moved from a traditional retailer to a *precision retailer* by achieving information superiority in its domain. Implementing this strategy required the coevolution of organization and process and, as part of the entry fee, an information infrastructure consisting of a sensory capability and semi-automated transaction capabilities. Wal-Mart employs this *infostructure* to generate a high level of competitive awareness in its retail ecosystem and exploits this awareness to create value.

The sensors include point of sales scanners that collect information on the 90 million (on average) transactions that take place each week.³⁰ Sharing this information with suppliers in near real time enables suppliers to optimally control production and distribution, as well

as manage their individual supply chains. In the words of Jack Welch, the CEO of General Electric:

*When Wal-Mart sells a [light]bulb on the register, it goes to my factory instantly—I [General Electric] make the bulb for the one they just sold. The enterprise system is now totally compressed with information.*³¹

This degree of self-synchronization emerged from the coevolution of organization and process. Originally, Wal-Mart had a central purchasing department. But when the decision was made to share information directly with suppliers, the need for this part of the organization went away. Costs were reduced and performance increased.

A high level of awareness is generated at each Wal-Mart store by fusing real-time information with historical and environmental information. To accomplish this, all transaction information is stored in a large data warehouse (24-plus terabytes) where it is analyzed with sophisticated data mining algorithms to extract trend data (e.g., seasonal trends, market basket trends).³² This is then combined with real-time transaction information to develop a high degree of localized awareness within each Wal-Mart store. For example, sales statistics for each 100,000-plus products are generated on a store-by-store basis, permitting department managers in each Wal-Mart store (there are 36 departments in the typical Wal-Mart store) to compare daily sales figures with historic sales figures from the previous day, the previous week, and the same periods the previous year. In addition, each department manager is able to determine in real

time existing inventory levels, the amount of product in transit (in-transit visibility), and inventory levels at neighboring Wal-Mart stores. This very high level of awareness enables local section managers to identify opportunities in near real time and take appropriate action to increase sales and revenues. Actions include repricing items to react to local competitors' pricing moves or prominently displaying items that are experiencing increased volume or those that are generating high margins.

Superior competitive awareness enables Wal-Mart to suppress costs, increase sales, and improve net earnings.

The Network Is the Market

In the financial services sector, where information is the life-blood of markets, the emergence of real-time awareness and real-time transaction capabilities is changing the dynamics of competition. Companies such as Charles Schwab and E*Trade have introduced capabilities for real-time on-line stock trading that create value by providing customers with new trading capabilities and reduced costs. These companies are using information and information technologies to achieve time compression and cost suppression. Time compression is enabled by capabilities that provide near real-time price awareness and enable near real-time transactions. Cost suppression is achieved in large measure by replacing the traditional approach of dealing directly with a broker via telephone or in person with more direct digital access. Employing a strategy based upon information superiority has enabled Schwab to emerge as the leading provider of

on-line trading services with a market capitalization that recently exceeded that of Merrill Lynch.³³

Similar value creation trends have emerged in the worldwide multitrillion dollar market for interest-bearing U.S. Government securities. In this market, the introduction of the *Autobahn* automated trading service by Deutsche Morgan Grenfell, Inc. (DMG) is fundamentally changing the dynamics of competition by creating a new trading ecosystem where *The Network is the Market*SM.

In the existing trader-centric ecosystem, the trader holds important information, placing him in a position of power. Customers potentially work with multiple traders to initiate and complete a transaction. The transaction is a three-step process involving generation of price awareness, selection of a trader, and execution of a transaction. Transaction timelines are dominated by access timelines, and service asymmetries emerge between large and small customers. For large customers, a transaction takes 30 to 90 seconds or so under ideal conditions. For small customers, a transaction can take an order of magnitude longer. When major market movements take place, competition based on time emerges as the dominant competitive dynamic and service asymmetries are amplified. When trading volumes are extremely large, traders can exploit their position of power by raising the minimum amount for trades.^{34 35} With *Autobahn*, DMG eliminates asymmetry with information superiority. The shift to network-centric operations enables DMG to provide all customers with 100 percent competitive space awareness in real time. This awareness is in the form of bid and ask prices for